Geothermal Study
for the
Newport Utilities Board Office Site
Newport, Tennessee

Performed For

Tennessee Valley Authority.

by

Earth Energy

Engineering, Inc.

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EARTH ENERGY

Engineering Inc.

P.O. Box 322

Big Stone Gap, Va. 24219

Thermal Conductivity Test Results
Newport Utilities Board

Earth Energy Engineering, Inc performed a thermal conductivity test at the Newport Utility Board future office site at Newport, Tennessee on January 23, 1999. Testing was done by Bill Nagel and Freddie Allison with a Ewbank portable test unit.

The test borehole was 300 feet in depth and 6" in diameter. A 1" inch loop was installed and the borehole was backfilled with # 8 clean stone. Static water level was detected at about 50 feet. The formations encountered were primarily black slate.

The thermal conductivity (**k**) value was determined to be **1.4 Btu/degree F-hr-foot**. This is an average conductivity per foot for the borehole. This value represents the rate at which the borehole and rock will transfer heat. All test equipment, methods, procedures, calculations and interpretations is done in accordance with the recommendations and guidelines of the International Ground Source Heat Pump Association.

Drill Log for Newport Utility Building Site

Hole # 1
SE corner of field

42 ft steel casing inserted and removed

From ft	To ft	Material	GPM
0	13	Clay	
14	16	River jack	
17	30	Clay	
30	36	Black slate	
36	36	(4 GPM Water cased off)	
36	50	Black slate	
50	52	Soft	2
52	75	Black slate	
75	75	Water	4
75	90	Black slate	
90	90	Water	4
90	130	Black slate	
130	130	Water	3
130	140	Black slate	
140	140	Water	2
140	150	Black slate	
150	164	Soft	5
164	190	Black slate	
190	210	Limestone	
210	214	Soft	20
214	301	Slate	
		Total water make	40

Hole # 2
Western end of field

42 ft steel casing inserted and removed

From ft	To ft	Material	GPM
0	3	Clay	
3	10	River jack	
10	30	Clay	
31	80	Black slate	
81	85	Soft	
85	98	Black slate	
98	98	Water	1
98	139	Black slate	
140	145	Soft	
146	169	Black slate	
170	172	Soft	
173	189	Black slate	
190	191	Soft	
192	192	Water	1
192	301	Black slate	
		Total water make	2

Ewbank
and associates
GEO SYSTEMS PROFESSIONALS

P.O. Box 148, Fairview, Oklahoma 73737 Phone/Fax 580-227-3352 E-mail ewbank@fairview-ok.net

Thermal Conductivity Testing

The beginning

Thermal conductivity testing was a concept that Dr. Jim Bose and Dr. Jeff Spitler of Oklahoma State University and the International Ground Source Heat Pump Association envisioned as an important design tool for geothermal installations. In 1994, Ewbank and Associates built the first portable thermal conductivity test unit.

Thermal conductivity

Thermal conductivity is expressed as btu/hour-degree F-foot. The btu's per hour that a borehole can transfer is dependent on depth and the number of degrees F the temperature at the borehole is different than the normal ground temperature. The more differential between the borehole temperature and the normal ground temperature, the more btu/hour/foot will be transferred

Important information

The size of a ground heat exchanger for a building at a given site is highly dependent on how well the ground transfers heat. To properly design a ground loop, the thermal conductivity of the soil or rock must be determined. If the conductivity is guessed too high, the ground loop will be too small, resulting in a system that fails or is not efficient. If the conductivity is guessed too low, the ground loop will be sized too large, resulting in unnecessary expense.

Estimating conductivity is not accurate

The thermal conductivity values for various soils and rocks can differ greatly among similar types. For instance, limestone can have a conductivity value ranging from 1 to 4. This represents different density, water content, and other factors. Also, most boreholes encounter layers of mixed formations and are not homogenous material. Given the wide range of values for a given material and the presence of multiple materials, accurately estimating the thermal conductivity value for a borehole is very difficult. Testing is the only method that can produce reliable results.

Calculating thermal conductivity

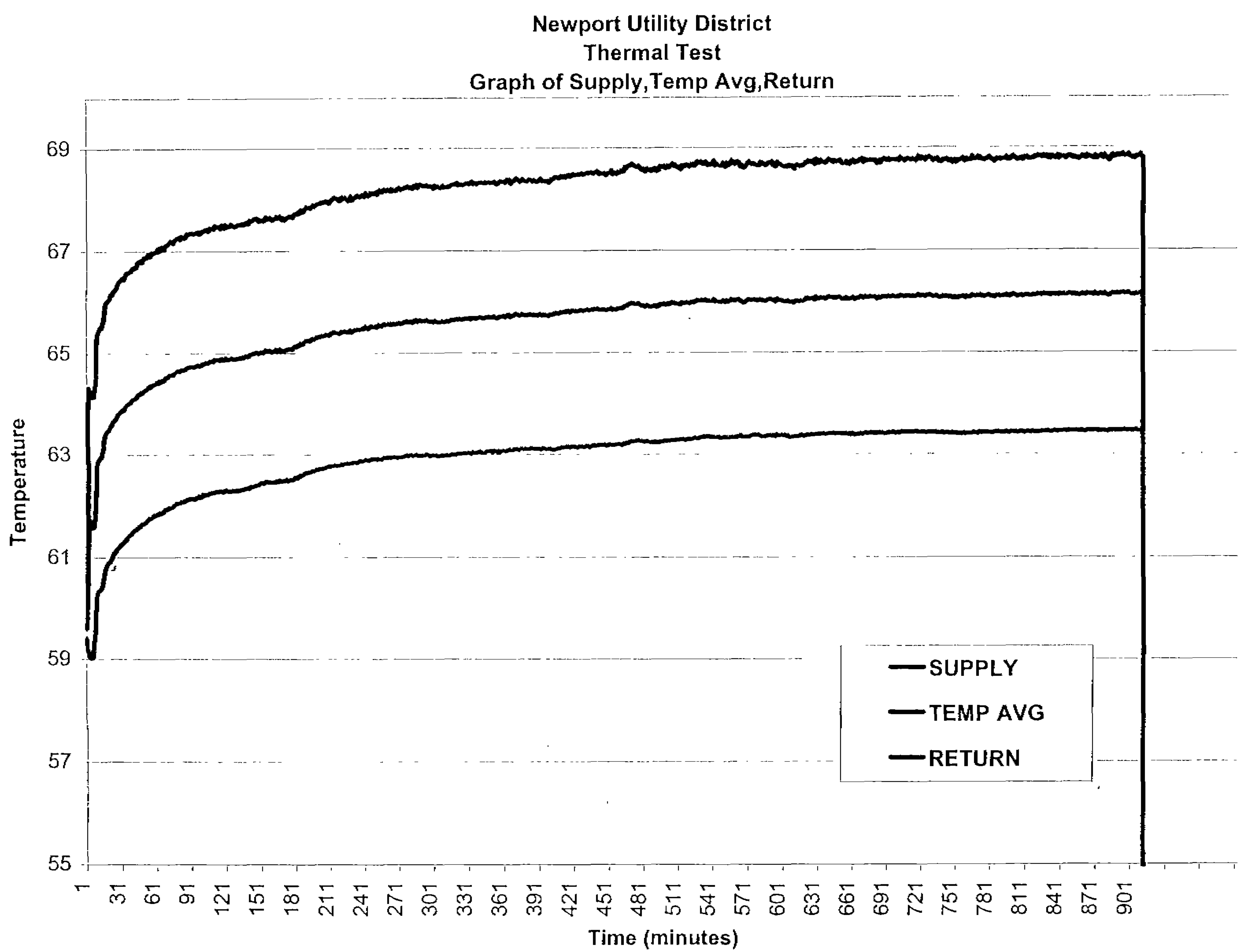
In simple terms, thermal conductivity is determined by adding heat to a circulating loop. The rate of temperature rise over time allows the thermal conductivity of the borehole to be calculated. The data obtained by the test unit represents the combined thermal conductivity of the system. The system includes the ground, the loop, and the material in the borehole. As the temperature rises over time, the portion of the increase that is attributable to the loop and borehole material becomes less and less. Consequently, the measured conductivity will often increase in the latter part of the test. This indicates that the borehole effects are relatively small and the temperature rise over time is basically due to the ground thermal conductivity. If the loop and borehole material is not highly conductive, or the borehole is large in diameter, the borehole will have a high resistance. This results in higher operating temperatures because the temperatures must be higher to move the heat through the inefficient borehole. The greater the disparity between the borehole conductivity and the ground conductivity, the longer the test must be run to accurately measure the ground conductivity.

Utilizing the thermal conductivity value

Any of the ground heat exchanger design methods, other than rule of thumb, require a thermal conductivity value. Computer design software, such as GLHEPRO, requires an input value for thermal conductivity. This value is an important variable in the resulting ground heat exchanger size. Measuring thermal conductivity through testing, and accurately calculating the heating and cooling loads will allow a ground loop to be designed that is properly sized for the application. Design models for installations that have unbalanced heating and cooling loads should be run for 10 to 20 years to ensure long-term success. Generally, the higher the thermal conductivity value, the greater the spacing should be used between boreholes.

IGSHPA and Oklahoma State University

Ewbank and Associates works closely with personnel from the International Ground Source Heat Pump Association and Oklahoma State University. Dr. Jim Bose, Dr. Marvin Smith, and Dr. Jeff Spitler have contributed greatly to the development of thermal conductivity testing. Dr. Smith and Ewbank have collaborated on several research projects concerning thermal conductivity. Research and development is continuing for equipment, test methods, and interpretation. All equipment, test methods, interpretation, and procedures are done in accordance with the guidelines and recommendations of the International Ground Source Heat Pump Association.


Newport Utility District
Thermal Test
Graph of Supply,Temp Avg,Return
Temperature
69
67
65
63
61
59
57
55
1
31
61
91
121
151
181
211
241
271
301
331
361
391
421
451
481
511
541
571
601
631
661
691
721
751
781
811
841
871
901
Time (minutes)
SUPPLY
TEMP AVG
RETURN

Newport Utility District
Thermal Test
Graph of Log Time of Temp Avg